Small Business Innovation Research/Small Business Tech Transfer

Solid-State, Electrochemical Micro-Sensors for Atmospheric Nitrogen and Carbon Dioxide Measurements at the Surface of Venus, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

Makel Engineering, Inc. (MEI) proposes to develop high temperature, solid state sensors to monitor carbon dioxide (CO2) and nitrogen (N2) in the Venus atmosphere. A harsh environment chemical sensor array suitable for measuring key trace species in the Venus atmosphere has been developed by MEI under a recent SBIR program. Currently there are no demonstrated chemical microsensors suitable to measure the two most abundant species (CO2 ~ 97% and N2~ 3%) in the Venus atmosphere at high pressure and high temperature conditions (CO2 and N2 exist as supercritical fluids near Venus surface). The proposed amperometric and potentiometric sensors are compatible with SiC electronics under development for Venus chemical sensing instruments, complementing recent and ongoing efforts to support Venus atmospheric analysis. Future missions which may descent through the atmosphere and operate on the surface of Venus measuring the composition of the atmosphere would benefit from this new capability to accurately measure small variations of N2 and CO2 concentration.

In Phase I, the focus will be on selection of suitable materials and development of designs for solid state sensors that are stable at high temperature and provide a path to quantitative measurement of carbon dioxide and nitrogen under Venus atmospheric conditions. Sensors with designs and material systems will be fabricated and tested. The most promising sensors will be selected for further development and maturation in Phase II. In Phase II, the sensors will be coupled with silicon carbide (SiC) based electronics being developed by MEI under the Hot Operating Temperature Technology (HOTTech) program, which will enable operation of chemical sensors for extended periods on the surface of Venus.

Anticipated Benefits

In addition to monitoring the CO2 and N2 concentration in the Venus atmosphere, the sensor can be used to monitor CO2 and N2 in the Mars atmosphere, as well as support of Mars in situ resource utilization (ISRU), such as capture and pressurization systems systems for capture, concentration and utilization of CO2 from the Mars atmosphere.

CO2 is generated in the anode of molted carbonate cells and consumed in the cathode. CO2 monitoring enables controlling addition of CO2 to make up deficiencies. Inert N2 is used to protect cell components. A CO2 sensor capable of measuring high concentration levels can be used in CO2 sequestration process, including monitoring the CO2 concentration prior to injection into storage sites, and monitoring concentration when injected in mature oil fields for Enhanced Oil Recovery (EOR).

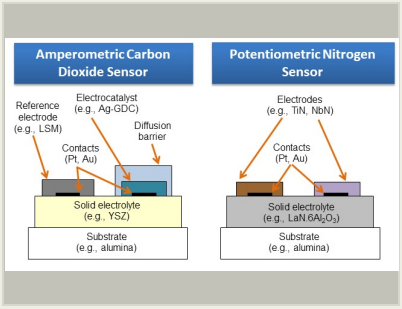

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Table of Contents

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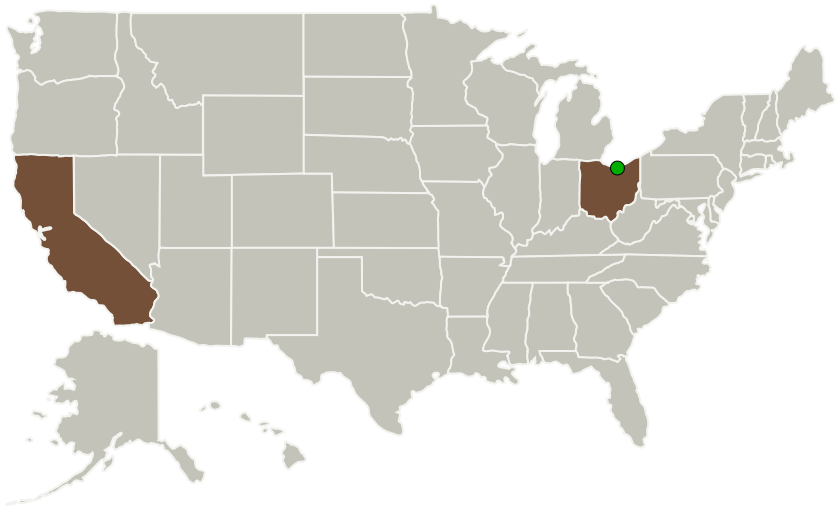
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Makel Engineering, Inc.	Lead Organization	Industry Small Disadvantaged Business (SDB)	Chico, California
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations	
California	Ohio

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141304)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Makel Engineering, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Darby B Makel

Co-Investigator:

Darby Makel

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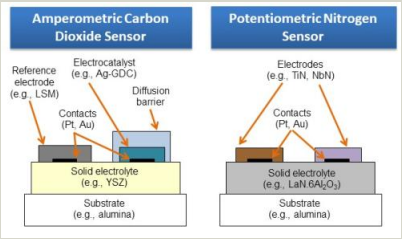
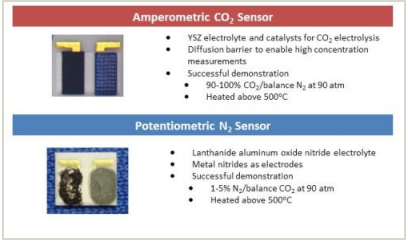
Images



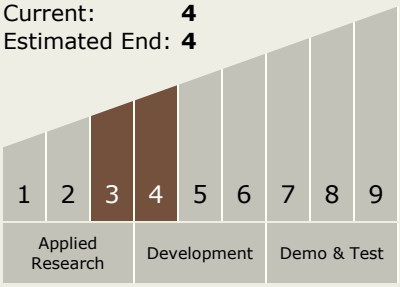
Briefing Chart Image
Solid-State, Electrochemical Micro-Sensors for Atmospheric Nitrogen and Carbon Dioxide Measurements at the Surface of Venus, Phase I *(https://techport.nasa.gov/image/131664)*



Final Summary Chart Image
Solid-State, Electrochemical Micro-Sensors for Atmospheric Nitrogen and Carbon Dioxide Measurements at the Surface of Venus, Phase I *(https://techport.nasa.gov/image/136139)*

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.4 Environment Sensors

Target Destination

Others Inside the Solar System